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Research Note

Estimation of heterosis for grain yield and quality traits in sweet corn (*Zea mays* var. *sacharata* L.)

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Abstract
The study was carried out to estimate heterosis for yield and biochemical quality traits in sweet corn (*Zea mays* var. *sacharata*) crosses. Forty five hybrids using diallel mating design excluding reciprocals were generated. These hybrids along with their ten parents and one standard check (Madhuri) were grown at IARI, New Delhi during *kharif*-2008 in randomized block design (RBD). Estimation of heterosis over standard check (HSC) 'Madhuri', mid-parent (HMP), and better parent (HBP) was calculated. The significant heterosis over standard check for grain yield was found in five crosses, and for sugar content in twelve crosses out of forty five. The HMP for grain yield was found in eighteen crosses and for sugar content in nine crosses. The HMP for grain yield and sugar content was found in IPSA-6134 × IPSA-6141, IPSA-6135 × IPSA-6136, and IPSA-6141 × IPSA-6142. One cross IPSA-6137 × IPSA-6139 showed HMP for protein content and grain yield. One cross IPSA-6136 × IPSA-6139 showed HMP for sugar content and protein content. The HBP was observed in IPSA-6135 × IPSA-6136, IPSA-6136 × IPSA-6139, IPSA-6138 × IPSA-6141, IPSA-6139 × IPSA-6140 and IPSA-6140 × IPSA-6141 for sugar content and IPSA-6134 × IPSA-6137, IPSA-6134 × IPSA-6141, IPSA-6134 × IPSA-6142, IPSA-6135 × IPSA-6139, IPSA-6140 × IPSA-6142, and IPSA-6141 × IPSA-6142 for grain yield. Two crosses IPSA-6135 × IPSA-6136 and IPSA-6141 × IPSA-6142 have the HBP for grain yield and sugar content. One cross IPSA 6137 × IPSA 6139 showed the HBP for protein and grain yield.

Keywords
Sweet corn, grain yield, heterosis, oil, protein, starch, sugar

Sweet corn (*Zea mays* var. *saccharata*), is a specialty corn which is characterized by translucent, horny appearance of kernel when matures and wrinkled when it dries. It has the mutant genes *su, su1* and *se*, which expresses in the endosperm. These mutants prevent the conversion of sugar into starch and thus such corn tastes sweet. Primary interest has been directed to carbohydrates, since in the milky stage, when the grain is harvested for food use, carbohydrate determines flavour and texture (Huelsen, 1954). Total sugar content in sweet corn at milky stage ranges from 25-30% as compared to 2-5% of normal corn (Sadaiah *et al*., 2013). Sweet corn breeding has been directed toward product quality and appearance as well as yield and agronomic performance. Many selection criteria are considered in sweet corn breeding and few germplasm sources fit the commercial standards. The genetic base of sweet corn breeding programme is relatively narrow and related inbreds often are crossed to make hybrids that meet the strict market requirements on quality and appearance (Tracy, 1994). The identification of parental inbred lines which give superior hybrids is the most costly and time consuming phase in corn hybrid development. *Per se* performance of maize inbred lines does not predict the performance of maize hybrids for grain yields (Hallauer and Miranda, 1988). It is even more complicated in sweet corn in which heterotic patterns are poorly defined (Revilla and Tracy, 1997). Recombining the same inbreds repeatedly without infusion of new heterotic combinations may lead to the depletion of heterosis (Revilla *et al*., 2000). In the Indian context due to the paucity of suitable hybrids of sweet corn, immediate attention and emphasis might be given to specific hybrid combinations showing highest productivity. Sweet corn breeders have often focused on improving quality and ear appearance, rather than on enhancing yield (Tracy, 1993). Moreover, all commercial sweet corn hybrids are based on one or more defective endosperm mutants, and production of high quality seed is more difficult for sweet corn than for most types of corn (Tracy, 1994). The emphasis on productivity as well as kernel biochemical components needs to be considered in the objective of sweet corn improvement. The quality parameters are relatively more important

especially because of direct consumption of sweet corn as vegetable and the preference of the consumers. In the present study, attempts were made to identify superior hybrid combinations using diallel method.

Ten diverse sweet corn inbred lines were used as parents. The crosses were made in all possible combinations excluding the reciprocals at Agricultural Research Station, Amberpet, Hyderabad during *rabi* 2007-08. The total 56 entries comprising of 45 F_1s and 10 parents and one standard check (Madhuri) were evaluated in RBD at Pusa, New Delhi during *kharif* 2008. Each entry has two rows/replication and each row has five meter length and spacing between rows was 75cm and plant to plant was 20cm. Recommended agronomic practices were followed for raising the good crop. Observations were recorded for 12 agronomic traits like days to tasseling, days to silking, days to maturity, plant height, cob placement height, cob length, cob width, rows/cob, grains/row, hundred grains weight and grain yield/plant. Five plants were taken from each row for recording observations like plant height, cob placement height, cob length, cob width, grain rows/cob and grains/row.

Four biochemical traits were taken viz., sugar, protein, starch and oil content of kernels. All the biochemical parameters were analyzed with the help of Near Infra-Red (NIR) spectrophotometer. Heterosis over mid-parent and better parent were calculated with the standard formula. Estimates of standard heterosis was calculated according to Virmani *et al*. (1982) and the significance of heterosis was tested using't' test.

The degree and direction of heterotic response varied not only from character to character but also cross to cross. Days to tasseling, silking and maturity are the important traits for consideration of crop duration. So, for these traits, negative heterosis is desirable. But other yield attributes plant height, cob placement height, cob length and width, number of grain rows cob^{-1}, number of grains row^{-1}, hundred grain weight and grain yield $plant^{-1}$, heterosis in positive direction is desirable. For quality traits except starch content in sweet corn, sugar content, protein content, and oil content, positive heterosis is desirable. Utility of heterosis depends upon the desirable direction of traits studied; whether the value of trait is required in higher or lower side. Here some traits like days to tasseling, days to silking and days to maturity and starch content are desirable in lower direction. So, heterosis should be significant in the negative direction for these traits for development of a hybrid. On the other hand, traits like yield and its attributes and quality traits like sugar content, protein content require heterosis in positive direction.

None of the cross exhibited significant desirable HSC, HMP and HBP for all the studied traits (Table 1). None of the cross exhibited HSC for cob width, while 20 for cob length, 5 for grain rows/cob, 14 for grains/row and 21 for hundred grains weight. Among the biochemical attributes for starch content 5, for protein content 1, and for oil content 22 crosses were heterotic. For the most important traits grain yield and sugar content the heterosis exhibited by 5 and 12 crosses, respectively. Only one cross IPSA-6134 × IPSA-6141 showed the heterosis for grain yield as well as sugar content and only one cross for protein content IPSA-6137 × IPSA-6141 with 6.4% standard heterosis. Literatures revealed that heterotic crosses for sugar content had also been reported (Zhao *et al*., 2002, and Khanduri *et al*., 2010).

For the most important trait grain yield/plant, the HMP was observed in the range of -36.97 to 21.31. The crosses showed the desirable HMP were IPSA-6135 × IPSA-6139, IPSA-6134 × IPSA-6141, IPSA-6134 × IPSA-6142, IPSA-6139 × IPSA-6141, IPSA-6134 × IPSA-6137, IPSA-6137 × IPSA-6141, IPSA-6135 × IPSA-6141, IPSA-6141 × IPSA-6142 and IPSA-6135 × IPSA-6136. For sugar content the high HMP was showed by IPSA-6140 × IPSA-6141, IPSA-6141 × IPSA-6142, IPSA-6140 × IPSA-6142, IPSA-6135 × IPSA-6136, IPSA-6138 × IPSA-6141, IPSA-6136 × IPSA-6141, IPSA-6136 × IPSA-6139, IPSA-6138 × IPSA-6142 and IPSA-6134 × IPSA-6141. The HMP for grain yield and sugar content was found in IPSA-6134 × IPSA-6141, IPSA-6135 × IPSA-6136, and IPSA-6141 × IPSA-6142. One cross IPSA-6137 × IPSA-6139 showed HMP for protein content and grain yield. One cross IPSA-6136 × IPSA-6139 showed HMP for sugar content and protein content.

The crosses showed the desirable HBP for grain yield were IPSA-6135 × IPSA-6139, IPSA-6139 × IPSA-6141, IPSA-6134 × IPSA-6142, IPSA-6134 × IPSA-6137, IPSA-6134 × IPSA-6141, IPSA-6137 × IPSA-6141, IPSA-6135 × IPSA-6136, IPSA-6135 × IPSA-6142, IPSA-6141 × IPSA-6142 and IPSA-6135 × IPSA-6137. HBP for sugar content was exhibited by IPSA-6140 × IPSA-6141, IPSA-6141 × IPSA-6142, IPSA-6139 × IPSA-6140, IPSA-6135 × IPSA-6136, IPSA-6140 × IPSA-6142 and IPSA-6138 × IPSA-6141. Two crosses IPSA-6135 × IPSA-6136 and IPSA-6141 × IPSA-6142 have the HBP for grain yield and sugar content. One cross IPSA 6137 × IPSA 6139 showed the HBP for protein and grain yield.

Some crosses were found to have all three types of heterosis *viz*., HSC, HMP and HBP (Table 2). For days to tasseling, days to silking, days to maturity, plant height, cob placement height, cob length, grain rows/cob, grains/row, hundred grain weight, grain yield, and sugar content were 3, 11, 5, 6, 6, 14, 4, 7, 6, 6, and 6 crosses, respectively. For days to tasseling, silking and maturity, all three types of heterosis were observed in IPSA-6133 × IPSA-6135, IPSA-6133 × IPSA-6142 and IPSA-6135 × IPSA-6140. But these three crosses are non-heterotic for both yield and sugar content. Reduction in the duration of crop also has its negative effect on yield improvement. So, still it is challenging to reduce the duration of hybrids with yield enhancement.

The quality parameters are relatively more important especially because of direct consumption of sweet corn as vegetable and the preference of the consumers. The overall results indicated that emphasis on productivity as well as kernel biochemical components may be considered in the objective of sweet corn hybrid development. Some crosses showing the best heterotic performance for grain yield also showed heterosis for some of the traits among days to tasseling, days to silking, days to maturity, plant height, cob placement height, cob length, cob width, grain rows cob^{-1}, grains row^{-1} and hundred grain weight.

Reference

Fonseca, S. and Patterson, F. 1968. Hybrid vigour in seven parent diallel crosses in common winter wheat (*Triticum aestivum* L.). *Crop Sci*., **8**: 85-95.

Hallauer, A. R. and De Miranda, F. J. B. 1988. Quantitative genetics in maize breeding. 2nd Ed. Iowa State Univ, Press.

Huelsen, V. A. 1954. Sweet corn. Interscience Publishers, New York.

Khanduri, A., Prasanna, B. M., Hossain, F. and Lakhera, P. C. 2010. Genetic analyses and association studies of yield components and kernel sugar concentration in sweet corn. *Indian J. Genet.*, **70**: 257-263.

Marshall, S. W. and Tracy, W. F. 2003. Sweet corn, p. 537–569. In: P.J. White and L. A. Johnson (eds.). Corn: Chemistry and technology. 2nd ed. American Assn. Cereal Chemists, St. Paul, MN.

Revilla, P. and Tracy, W. F. 1997. Heterotic patterns among open pollinated sweet corn cultivars. *J. Am. Soc. Hortic. Sci.*, **122**: 319-324.

Revilla, P., Velasco, P., Vales, M. I., Malvar, R. A. and Ordas, A. 2000. Cultivar heterosis between sweet and Spanish field corn. *J. Am. Soc. Hortic. Sci.*, **125**: 684-688.

Sadaiah, K., Reddy, V. N. and Sudheer Kumar, S. 2013. Heterosis and combining ability studies for sugar content in sweet corn (*Zea mays saccharata* L.). *IJSRP*, **3**: 1-5.

Tracy, W. F. 1993. Sweet corn: 777-807. In: G. Kalloo and B. O. Bergh (Eds.) Genetic improvement of vegetable crops. Pergamon. Oxford. U. K.

Tracy, W. F. 1994. Sweet corn, p. 147-187. In: A. R. Haullauer (ed.) Specialty types of maize. CRC Press, Boca Raton, Fla.

Virmani, S. S., Aquino, R. O. and Khush, G. S. 1982. Heterosis breeding in Rice (*Oryza sativa* L.). *Theor. Appl. Genet*., **63**: 373-380.

Zhao Yuanzeng, Wang Yulan, Zhao Rengui and Chen Zhanyu 2002. Study on the combining ability of dissolvable total sugar trait in super- sweet corn. *J. Jilin Agric. Uni*., **24**: 11-14.

Table 1. HSC, HMP and HBP for grain yield plant^{-1} and sugar content of crosses

Crosses	Grain yield plant^{-1} (g)			Sugar content (%)		
	HSC	HMP	HBP	HSC	HMP	HBP
IPSA-6133 × IPSA-6134	-1.80	-1.20	-7.38*	-45.28**	-59.07**	-61.61**
IPSA-6133 × IPSA-6135	-3.01	-1.21	-8.52**	-41.88**	-46.39**	-53.46**
IPSA-6133 × IPSA-6136	7.82*	10.09*	1.69	-51.22**	-57.42**	-60.94**
IPSA-6133 × IPSA-6137	-9.23**	-7.77	-14.38**	-14.46**	-24.87**	-31.50**
IPSA-6133 × IPSA-6138	6.46	6.07	0.41	-50.43**	-56.89**	-60.31**
IPSA-6133 × IPSA-6139	2.09	5.55	-3.71	-43.97**	-49.34**	-55.13**
IPSA-6133 × IPSA-6140	2.96	-4.35	-5.78	-10.25**	-26.96**	-28.13**
IPSA-6133 × IPSA-6141	1.02	4.44	-4.72	-41.94**	-52.3**	-53.51**
IPSA-6133 × IPSA-6142	3.93	6.23	-1.97	-35.43**	-39.63**	-48.29**
IPSA-6134 × IPSA-6135	-3.16	5.78	4.40	6.68	-9.00*	-25.16**
IPSA-6134 × IPSA-6136	3.79	13.67*	11.88**	11.63**	-9.53*	-21.69**
IPSA-6134 × IPSA-6137	7.67*	17.30**	16.07**	-30.32**	-43.2**	-51.12**
IPSA-6134 × IPSA-6138	1.51	8.29	7.18*	26.69**	2.31	-11.12**
IPSA-6134 × IPSA-6139	1.36	12.51*	9.27**	-0.11	-16.35**	-29.92**
IPSA-6134 × IPSA-6140	-36.33**	-36.97**	-41.73**	-2.74	-26.17**	-31.77**
IPSA-6134 × IPSA-6141	7.33*	19.14**	15.71**	42.69**	9.30*	0.10
IPSA-6134 × IPSA-6142	7.82*	18.21**	16.23**	-10.57**	-22.77**	-37.26**
IPSA-6135 × IPSA-6136	2.96	14.29**	13.98**	16.55**	18.84**	11.82**
IPSA-6135 × IPSA-6137	2.96	13.67*	13.37**	5.70	8.55	2.79
IPSA-6135 × IPSA-6138	4.91	13.39*	10.77**	-16.30**	-15.03**	-20.36**
IPSA-6135 × IPSA-6139	7.82*	21.31**	19.35**	-13.01**	-7.55	-9.65**
IPSA-6135 × IPSA-6140	3.45	3.65	-5.33	-16.86**	-21.87**	-31.23**
IPSA-6135 × IPSA-6141	2.48	15.30**	13.44**	3.88	-1.28	-12.37**
IPSA-6135 × IPSA-6142	2.96	14.41**	13.98**	-5.82	4.07	2.46
IPSA-6136 × IPSA-6137	-27.10**	-19.30**	-19.73**	-27.35**	-29.82**	-30.29**
IPSA-6136 × IPSA-6138	-12.34**	-5.00	-7.44*	-15.81**	-19.57**	-19.9**
IPSA-6136 × IPSA-6139	-6.99*	4.93	3.51	10.99**	10.70*	6.49
IPSA-6136 × IPSA-6140	-16.12**	-15.76**	-23.24**	1.44	-9.88*	-16.1**
IPSA-6136 × IPSA-6141	-30.55**	-21.64**	-22.70**	24.78**	12.03*	5.27
IPSA-6136 × IPSA-6142	-12.87**	-2.92	-3.03	-0.8	2.63	-4.83
IPSA-6137 × IPSA-6138	4.42	12.57*	10.26**	-14.93**	-18.18**	-19.07**
IPSA-6137 × IPSA-6139	1.80	14.22*	12.09**	0.05	0.49	-2.71
IPSA-6137 × IPSA-6140	2.72	2.67	-6.00*	4.79	-6.33	-13.33**
IPSA-6137 × IPSA-6141	4.37	17.11**	14.92**	5.61	-4.59	-10.91**
IPSA-6137 × IPSA-6142	-2.43	8.13	7.43*	-4.50	-0.47	-7.13*
IPSA-6138 × IPSA-6139	-5.49	3.79	-0.21	4.76	4.03	-0.33
IPSA-6138 × IPSA-6140	5.97	3.90	-3.02	6.75	-5.54	-11.71**
IPSA-6138 × IPSA-6141	-2.57	6.99	2.87	29.09**	15.44**	8.90**
IPSA-6138 × IPSA-6142	2.48	11.17*	8.21*	7.12*	10.34	1.92
IPSA-6139 × IPSA-6140	2.96	4.69	-5.78	36.20**	25.42**	12.65**
IPSA-6139 × IPSA-6141	2.87	17.67**	17.67**	5.61	-1.68	-10.91**
IPSA-6139 × IPSA-6142	-4.57	7.79	6.45	-4.29	3.27	-0.60
IPSA-6140 × IPSA-6141	-2.48	-0.84	-10.76**	57.98**	31.96**	30.67**
IPSA-6140 × IPSA-6142	-2.87	-2.34	-11.11**	32.30**	26.02**	9.43**
IPSA-6141 × IPSA-6142	1.75	14.92**	13.49**	35.90**	30.91**	14.64**

*, **Significant at p=0.05 and p=0.01 levels, respectively

Table 2. Promising crosses for all three types of heterosis for different traits

S N	Crosses	HSC	HMP	HBP
Days to tasseling (No.)				
1	IPSA-6133 × IPSA-6135	-6.29**	-7.90**	-7.59**
2	IPSA-6133 × IPSA-6142	-6.29**	-10.96**	-8.22**
3	IPSA-6135 × IPSA-6140	-4.20**	-6.80**	-5.52**
Days to silking (No.)				
1	IPSA-6133 × IPSA-6135	-4.43**	-4.73*	-3.82*
2	IPSA-6133 × IPSA-6136	-3.80*	-5.88*	-3.18*
3	IPSA-6133 × IPSA-6139	-8.23**	-8.81**	-7.64**
4	IPSA-6133 × IPSA-6142	-6.33**	-9.20**	-5.73**
5	IPSA-6134 × IPSA-6135	-6.33**	-9.20**	-7.50**
6	IPSA-6134 × IPSA-6136	-3.80*	-8.43**	-8.43**
7	IPSA-6134 × IPSA-6138	-3.80*	-5.88*	-3.18*
8	IPSA-6134 × IPSA-6139	-5.70**	-8.87**	-7.45**
9	IPSA-6135 × IPSA-6139	-3.80*	-5.30*	-5.00**
10	IPSA-6135 × IPSA-6140	-6.33**	-6.03*	-4.52**
11	IPSA-6135 × IPSA-6141	-5.70**	-8.02**	-6.88**
Days to maturity (No.)				
1	IPSA-6133 × IPSA-6135	-3.69**	-5.05**	-4.86**
2	IPSA-6133 × IPSA-6139	-2.46*	-4.42**	-4.03**
3	IPSA-6133 × IPSA-6142	-3.28**	-5.41**	-4.84**
4	IPSA-6134 × IPSA-6142	-3.69**	-5.81**	-5.24**
5	IPSA-6137 × IPSA-6139	-4.51**	-5.67**	-4.51**
Plant height (cm)				
1	IPSA-6133 × IPSA-6142	18.49**	32.34**	25.18**
2	IPSA-6134 × IPSA-6136	6.90*	35.59**	24.68**
3	IPSA-6134 × IPSA-6137	12.47**	34.85**	18.54**
4	IPSA-6134 × IPSA-6139	5.79*	24.02**	7.22*
5	IPSA-6137 × IPSA-6141	8.02**	14.79**	13.85**
6	IPSA-6137 × IPSA-6142	8.46**	14.45**	14.32**
Cob placement height (cm)				
1	IPSA-6134 × IPSA-6135	8.02*	40.06**	32.37**
2	IPSA-6134 × IPSA-6136	16.98**	34.42**	26.53**
3	IPSA-6134 × IPSA-6137	19.81**	36.19**	27.00**
4	IPSA-6135 × IPSA-6141	8.49*	36.09**	25.00**
5	IPSA-6135 × IPSA-6142	13.68**	28.88**	9.55*
6	IPSA-6138 × IPSA-6139	15.09**	42.69**	36.31**
Cob length (cm)				
1	IPSA-6133 × IPSA-6134	8.82*	39.73**	33.37**
2	IPSA-6133 × IPSA-6135	14.76**	34.36**	28.60**
3	IPSA-6133 × IPSA-6136	27.23**	40.66**	28.10**
4	IPSA-6133 × IPSA-6141	9.69*	21.27**	10.45*
5	IPSA-6134 × IPSA-6136	15.44**	33.09**	16.23**
6	IPSA-6134 × IPSA-6138	9.99*	25.60**	8.92*
7	IPSA-6135 × IPSA-6136	13.37**	20.25**	14.15**
8	IPSA-6135 × IPSA-6141	8.52*	15.11*	9.27*
9	IPSA-6135 × IPSA-6142	8.67*	30.05**	21.78**
10	IPSA-6136 × IPSA-6138	23.28**	23.10**	22.09**
11	IPSA-6136 × IPSA-6142	16.42**	31.39**	17.21**
12	IPSA-6137 × IPSA-6138	26.25**	17.02**	9.97**
13	IPSA-6138 × IPSA-6139	15.39**	22.14**	14.28**
14	IPSA-6138 × IPSA-6142	14.37**	27.89**	13.27**

Table 2. Contd..

S N	Crosses	HSC	HMP	HBP
Grain rows/cob (No.)				
1	IPSA-6133 × IPSA-6139	7.08*	57.97**	46.45**
2	IPSA-6133 × IPSA-6141	7.08*	50.13**	33.53**
3	IPSA-6135 × IPSA-6141	9.91**	42.07**	37.06**
4	IPSA-6136 × IPSA-6139	7.08*	35.93**	26.82**
		Grains/row (No.)		
1	IPSA-6133 × IPSA-6135	17.74**	38.16**	13.65**
2	IPSA-6133 × IPSA-6141	10.80*	63.57**	61.42**
3	IPSA-6133 × IPSA-6142	14.65**	63.67**	56.49**
4	IPSA-6137 × IPSA-6138	26.35**	27.00**	19.59**
5	IPSA-6137 × IPSA-6141	29.31**	48.38**	22.38**
6	IPSA-6138 × IPSA-6139	26.22**	35.64**	35.26**
7	IPSA-6138 × IPSA-6142	17.35**	40.90**	25.76**
		Hundred grain weight (g)		
1	IPSA-6133 × IPSA-6138	66.47**	33.49**	31.75**
2	IPSA-6134 × IPSA-6135	36.23**	27.99**	23.64**
3	IPSA-6134 × IPSA-6137	42.51**	31.13**	29.35**
4	IPSA-6135 × IPSA-6137	22.46**	16.69*	14.25**
5	IPSA-6136 × IPSA-6140	28.14**	33.54**	15.99**
6	IPSA-6137 × IPSA-6141	34.13**	22.40**	19.79**
		Grain yield/plant (g)		
1	IPSA-6134 × IPSA-6137	7.67*	17.3**	16.07**
2	IPSA-6134 × IPSA-6141	7.33*	19.14**	15.71**
3	IPSA-6134 × IPSA-6142	7.82*	18.21**	16.23**
4	IPSA-6135 × IPSA-6139	7.82*	21.31**	19.35**
		Sugar content (%)		
1	IPSA-6135 × IPSA-6136	16.55**	18.84**	11.82**
2	IPSA-6138 × IPSA-6141	29.09**	15.44**	8.90**
3	IPSA-6139 × IPSA-6140	36.20**	25.42**	12.65**
4	IPSA-6140 × IPSA-6141	57.98**	31.96**	30.67**
5	IPSA-6140 × IPSA-6142	32.30**	26.02**	9.43**
6	IPSA-6141 × IPSA-6142	35.90**	30.91**	14.64**
		Starch content (%)		
1	IPSA-6140 × IPSA-6141	-6.7	5.4	-4.85*
2	IPSA-6137 × IPSA-6139	-6.35**	-4.87	-6.94**
3	IPSA-6134 × IPSA-6141	-5.41**	5.57	-5.6**
4	IPSA-6135 × IPSA-6138	-5.34*	-4.56	-7.21**
5	IPSA-6139 × IPSA-6141	-4.98*	8.45*	-1.28
		Oil content (%)		
1	IPSA-6134 × IPSA-6141	23.49**	7.92	7.36*
2	IPSA-6139 × IPSA-6140	19.89**	5.91	3.01
3	IPSA-6140 × IPSA-6142	19.34**	12.73*	2.54
4	IPSA-6137 × IPSA-6142	17.73**	9.61	-1.47
5	IPSA-6140 × IPSA-6141	16.93**	1.59	0.47

*, **Significant at p=0.05 and p=0.01 levels, respectively